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ABSTRACT

Compared were the performance of third grade pupils on division of whole numbers using a commercial microcomputer drill program (Milliken Publishing Company Math Sequence) with the performance of another group using printed drill materials (mimeographed sheets of 50 problems from each level of the computer drill program). Using a matched pairs design, 48 students from three third-grade classes in an affluent suburban school district in the Southeast were allocated to the computer or paper drill group. No significant difference between the two groups was found on the pretest. The difference between the two groups on the progress test administered at the end of the first week was significant, but on all other progress tests and on the posttest no significant differences in mean performance were found. Student progress toward mastery favored the print group. At the end of the 5-week study, 20 members of the print group and 18 members of the computer group met the specified mastery criterion of 90 percent on the 50-item test. Thus, the sound, color, graphics, and immediate feedback in the computer program had no apparent effect on student achievement and were not as efficient in enabling students to reach the specified mastery level. (MNS)

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A COMPARISON OF THIRD GRADE STUDENT PERFORMANCE IN DIVISION OF WHOLE NUMBERS USING A MICROCOMPUTER DRILL PROGRAM AND A PRINT DRILL PROGRAM

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The microcomputer is an educational tool of unprecedented power; however, the potential is great for making serious mistakes when microcomputers are being considered as an aid in the teaching of content or skills. One serious mistake is to adopt computer assisted instructional materials without evidence of effectiveness and efficiency. Computer assisted learning methods need to be compared with and evaluated against more traditional methods of teaching. Commercial software vendors do not routinely furnish empirical evidence that their programs achieve what they claim. Many of the software evaluation checksheets in current vogue address procedural aspects such as ease of loading; documentation; and effectiveness of color, graphics, and sound. Before teachers abandon traditional modes of instruction for computer assisted instructional methods, they should ask software vendors for evidence of effectiveness and efficiency of the microcomputer programs being considered. If no such evidence is available, efforts should be made to obtain factual information by conducting classroom research.

Problem Statement

A study conducted at The University of Alabama in January and February, 1984, investigated the efficacy of a computer mathematics drill and practice program in a classroom setting. The problem of the study was to compare the performance of third-grade students on division of whole numbers using a commercial microcomputer drill program with the performance of another group using traditional printed drill materials.

Two hypotheses were tested in order to determine the effectiveness and efficiency of drill and practice methods used in third-grade mathematics. The first hypothesis, to test effectiveness, was:

> There will be no significant difference in the performance of third-grade mathematics students using a computer drill and practice program and those using traditional print materials.

The second hypothesis, to test efficiency, was:

> At least 80% of all students in both groups will reach 90% mastery on a 50-item divison test by the end of five weeks.

The Microcomputer Drill Program

The Milliken Publishing Company Math Sequences package (1980), consisting of twelve diskettes, is designed to provide drill and practice for students in grades 1 through 8. According to the accompanying teacher's manual, the division diskette is deemed appropriate for students in the third grade. The publisher recommends that the package is best used to provide students with individual drill and practice in mathematical operations which have already been introduced by the teacher.

The division diskette contains 64 problem levels. An indication of the progression of the program can be ascertained from Table 1, which shows the characteristics of problems generated at selected program levels. At each

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Insert Table 1 about here.

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level, problems are randomly generated by the computer program. A question mark appears on the screen in the location of requested input. The student then enters what he or she considers to be the correct response. Two types of reinforcement are provided for correct answers, with the teacher or

student being able to choose the type desired. The first type, animation, consists of cartoon-like characters; the other type consists of phrases such as "Well done" and "Good job".

Students are generally given two chances to work a problem correctly. On problems such as long division, which require a greater number of operations, students are given extra chances based upon a formula that gives one additional chance for the completion of every seven correct responses. If a problem is answered incorrectly, the correct answer is presented and the students are requested to "study it".

To advance to the next level, the student must meet achievement criteria which can be specified by the teacher. The range of achievement criteria which can be set is 3 - 20 problems to be completed, 70 - 95% mastery level, and 30 - 70% failure level. When a student completes the number of problems specified and achieves mastery, he or she advances to the next problem level. The computer program drops the student one problem level if three consecutive problems are missed, or if the student's score falls below the assigned failure level after completing the specified number of problems. If the student fails the first assigned level, he or she is told to see the teacher; the computer program will not allow the student to reenter the sequence until a new assignment has been given. As long as a student's overall score is between the specified mastery and failure levels, the computer will continue to generate problems at that level until the number of problems previously specified has been reached.

The Print Drill Program

Printed drills consisted of mimeographed sheets of 50 problems from each level of the computer drill program. Three different drill sheets were developed for each problem level. The problems for each drill sheet were

randomly generated by the computer program. Since problem generation was random, identical problems were used whenever they occured.

Method

The study was conducted during a five-week period in January and February, 1984. All subjects were students in the third grade of an affluent suburban school district in the Southeast. Using a matched pairs design, students from three third-grade classes were allocated to a computer drill and practice group or to a print drill and practice group. All students were at the same academic level in the subject area, as determined by most recent grade in the course. Pairs were matched on the basis of teacher recommendation and scores on a pre-test of the material to be covered. Forty-eight subjects were used in the experiment, with 24 being assigned to each of the experimental groups.

To be consistent with classroom objectives for the course, 50 of the available 64 problem levels (Table 1) were used during the five-week time period devoted to the study. Achievement criteria set for each problem level were 20 problems to be completed, 90% mastery, and 70% failure level.

All students received 30 minutes of classroom mathematics instruction each day. The computer group was then required to use the computer program for approximately 20 minutes of drill and practice while the print group was given worksheets for its 20-minute practice sessions. As the computer group advanced through the levels of instruction, meeting the experimental criteria, the computer program provided the next level of instruction. Performance of the print group students was monitored by the classroom teachers using the same experimental criteria. If student performance did not meet the experimental criteria, alternate versions of the print drill and practice sheets were available for additional practice. When experimental

criteria were met, the student was given the worksheet for the next problem level by the classroom teacher.

Two equivalent 50-item paper and pencil tests were constructed for use as pre-tests, progress tests, and post-tests. The tests incorporated every combination of numbers and format contained in the computer drill and practice program through Level 50. At the end of each week, alternating versions of the test were administered to determine student progress toward the specified mastery level of 90%. At the completion of the experiment, the post-test was administered to all subjects. Tests were collected each week from the classroom teachers and scored by the research team. Teachers and students did not receive results of the tests.

Results

Program effectiveness results were determined each week by comparing progress test scores. Program efficiency results were determined each week by noting the number of students reaching the 90% mastery criterion.

Program Effectiveness

Analysis of weekly test performance utilized a two-tailed "t" test between means. The level of significance for each test was set at .05. When using multiple "t" tests the formula $P(\text{overall}) = 1 - (1 - .05)^6 = .26$ applies. The two-tailed "t" test with 46 degrees of freedom revealed no significant difference between the two groups on the pre-test. The difference between the two groups on the progress test administered at the end of the first week was significant ($p>.01$). On all other progress tests and the post-test there were no significant differenceces between mean performance of the two groups. The performance scores of the two groups are presented in Table 2.

Insert Table 2 about here.

Program Efficiency

Five members of the print group and 4 members of the computer group met the mastery criterion of 90%, 45 items correct on the 50-item pre-test. As shown on Table 3, 17 of the 24 students in the print group obtained mastery level by the end of the first week. In contrast, only 6 members of the computer group had reached mastery level by the end of the first week. Thereafter, student progress toward mastery was approximately equal. At the end of the experiment, 20 members of the print group and 18 members of the computer group met the spacified mastery criterion of 90% on a 50-item test.

Insert Table 3 about here.

Findings and Implications

Hypothesis 1

This study found essentially no difference between the performance of students using a computer drill and practice mathematics program and students using traditional print drill and practice materials. The null hypothesis that there would be no significant difference in the performance of third-grade mathematics students using a computer drill and practice program and those using traditional print materials could not be rejected.

The poorer performance of the computer group on Progress Test 1 may be attributed to lack of familiarity with computer drill and practice materials. The majority of the subjects in the computer group were unsophisticated computer users. The computer program required subjects to depress a limited range of keys, the number keys and the return key; therefore, by the end of

the second week when the mean difference between the performance of the two groups was not significant, the computer group was responding to computer program prompts with efficiency.

Close observation of the computer group revealed that after the newness of using the computer wore off, some of the subjects became impatient as they waited for the cartoon-like characters and reinforcement messages to appear on the screen. The print group could readily move from problem to problem; the computer group had to wait until the graphic reinforcement message was generated and displayed; they had to wait again until the next problem was randomly generated. These delays, although short, may have adversely affected the performance of the computer group.

The print group had to wait until the teacher graded the entire worksheet to learn which problems were not correct, while the computer group received immediate feedback from the computer program. Both techniques appeared to be equally effective in producing progress toward mastery of the materials. The question of delayed feedback as compared to immediate feedback should be the subject of further research.

The use of sound, color, graphics, and printed messages in the computer program had no apparent effect upon student achievement. While these techniques may have some motivational value, they did not translate into significantly better student performance in this experiment. Further research is needed to answer questions such as:

> Is receiving reinforcement from a computer generated cartoon character, a computer generated message, or a synthesized computer voice more effective than receiving it in the traditional manner from a teacher?
>
> Is student performance measurably improved by the presence of instant gratification, flashing lights, catchy jingles, bleeps, gurgles, games, cartoon characters, color, and graphics? Do these techniques provide any assurance that learning is taking place?

The finding that there was no significant difference in the performance of students using computer drill and practice materials as compared to students using print materials has some important implications for computer using classroom teachers. Considering the cost of computer equipment and software, computer using teachers must become very selective in the use of computer based teaching materials. Only computer based instructional materials with demonstrated effectiveness and superiority should be adopted. It is not enough that computer based materials be as good as traditional materials, they must be proven to be superior in order to justify their adoption.

Computer software vendors must be more forthright in providing information concerning the performance value of their products, in contrast to procedural and motivational values. In particular, they should provide data demonstrating that their materials improve student effectiveness. The crucial question to be answered is "Does the use of a computer program produce more student growth than time spent reading, discussing, interacting, and employing other traditional methods"?

There is a very real possibility that educators are expending vast amounts of money needlessly or that they are not utilizing computers and computer based instructional materials to the best advantage. If classroom teachers conclude that they have been "oversold" on the value and merit of certain computer software programs, a technological backlash may occur with teachers rejecting even those materials which do offer improved learning effectiveness for students.

Classroom teachers utilizing traditional print materials with demonstrated effectiveness should be reluctant to abandon this method until it has been empirically demonstrated that other methods and procedures are

more effective. They should not allow themselves to be intimidated by current fads, which may prove to be transitory in nature.

Hypothesis 2

This study found that in a 5-week period a greater number of students using traditional print drill and practice materials reached mastery level in division than reached it using computer drill materials. The hypothesis that at least 80% of all students in both groups would reach 90% mastery on a 50-item divison test by the end of five weeks was rejected.

The amount of time necessary to reach the prescribed criterion is an important consideration when evaluating the efficacy of instructional materials. The finding that the computer based materials were less efficient in producing student learning than traditional print drill materials has important implications for educators. Time is an educator's most valuable resource; it must not be squandered. Where print materials are found to be more efficient, it is difficult to justify the adoption of computer based materials.

The vast amount of experience that students typically have with traditional print materials can be drawn upon in the learning of new skills and information. To fail to capitalize upon this prior practice and prior learning without good and serious reason is inefficient and potentially harmful to students.

Summary

During a five-week period computer mathematics drill and practice materials were compared with print mathematics drill and practice materials in a third-grade classroom setting. Achievement criteria included both effectiveness and efficiency measures. No significant differences were found

in the effectiveness of computer and print materials. Students utilizing print materials were more efficient in reaching the specified mastery level. This study provides evidence that some commercially available computer programs produce no better results than traditional teaching methods. Teachers should require producers of classroom materials to supply convincing evidence of the efficacy of their products prior to adoption.

Table 1
Computer Mathematics Sequences Package - Divison Diskette

Problem Level	Description	Problem Level Examples
1	Missing factors 0 - 9 Multiplicands 1 - 2 Products 0 - 20 (Multiples of 2)	? x 2 = 10
10-11	Missing quotients 1 - 9 Divisors 1 or 10 Dividends 1 - 9 and 10 - 90 (Multiples of 10)	8 / 1 = X X 10) 70
20-21	Missing quotients 1 - 9 Divisor is 4 Dividends 4 - 36 (Multiples of 4)	24 / 4 = X X 4) 16
30	Missing factors 0 - 8 Multiplicand is 8 Product 0 - 72 (Multiples of 8)	? x 8 = 0
40	Quotients 1 - 9 Divisors 2 - 9 Dividends 10 - 19 Remainders possible	X 2) 17
50	Quotients 1000 - 4999 Divisors 2 - 9 Dividends 1000 - 9999 Remainders possible	XXXX 7) 8234
60	Quotients 1 - 99 Divisors 10 - 99 Dividends 100 - 999 Remainders possible	X 39) 247
62-64	Quotients 100 - 999 Divisors 10 - 99 Dividends 1000 - 98,999 Remainders	XXX 47) 36782

Table 2
Performance of Print and Computer Students on 50-Item Division Test

Student No.	Print Pre-Test	Compute Pre-Test	Print Pro-gress 1	Compute Pro-gress 1	Print Pro-gress 2	Compute Pro-gress 2	Print Pro-gress 3	Compute Pro-gress 3	Print Pro-gress 4	Compute Pro-gress 4	Print Post-Test	Compute Post-Test
1	49	49	49	49	50	48	49	50	49	49	50	49
2	48	48	50	48	49	49	49	49	50	50	50	50
3	47	47	47	49	50	48	48	48	49	49	49	49
4	47	47	44	49	46	47	47	48	48	49	49	49
5	47	42	49	42	48	42	49	43	50	49	47	47
6	44	42	46	42	43	49	45	49	47	50	46	47
7	44	30	48	45	47	47	48	47	49	49	48	48
8	43	28	47	28	46	37	47	44	48	47	48	47
9	41	27	49	26	50	31	49	34	49	39	50	36
10	38	27	45	27	46	37	49	47	48	47	48	47
11	38	26	48	36	49	36	49	41	49	47	50	48
12	32	23	47	44	48	44	49	46	50	48	50	49
13	31	21	48	21	45	36	47	39	49	36	47	39
14	27	21	47	21	48	40	50	46	50	50	50	46
15	25	19	46	19	32	37	40	29	48	38	44	43
16	24	15	46	16	45	46	48	50	49	50	47	47
17	14	9	46	49	46	49	39	50	46	50	49	48
18	6	8	13	29	41	48	35	48	24	50	27	47
19	5	7	46	39	36	41	42	29	49	45	48	45
20	4	7	39	38	26	43	37	40	48	42	43	40
21	3	7	40	38	31	49	40	47	36	48	48	46
22	2	5	35	15	49	28	45	35	49	36	48	31
23	2	3	44	39	20	47	20	46	44	50	44	49
24	1	2	39	15	44	33	49	35	49	33	46	32
Mean	27.58	23.33	44.0[illegible]	34.33	43.13	42.17	44.58	43.33	46.96	45.88	46.92	44.96
S. D.	18.14	15.78	7.59	12.00	8.15	6.42	6.83	6.59	5.68	5.38	4.70	5.39
T-Test	.87		3.36		.45		.66		.68		1.34	
Significant			@ p = .01									

df = 46 p = .05 each test

Table 3
Time to Criterion Score of 90% on 50-Item Division Test

Time to Criterion	Print Group N = 24		Computer Group N = 24	
	No.	%	No.	%
Pretest	5	20.8	4	16.7
Week 1	17	70.8	6	25.0
Week 2	16	66.7	11	45.8
Week 3	17	70.8	14	58.3
Week 4	21	87.5	18	75.0
Week 5	20	83.3	18	75.0